

DOCUMENT RESUME

ED 246 787

HE 017 510

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TITLE Student Achievement in High Technology Programs--Community College vs. University Mathematical Preparation. AIR 1984 Annual Forum Paper.
PUB DATE May 84
NOTE 17p.; Paper presented at the Annual Forum of the Association for Institutional Research (24th, Fort Worth, TX, May 6-9, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; Calculus; *College Mathematics; College Transfer Students; *Community Colleges; Comparative Analysis; *Computer Science; Educational Background; *Engineering; Grades (Scholastic); Higher Education; Institutional Research; Prerequisites; *Universities
IDENTIFIERS *AIR Forum

ABSTRACT

Results of a study that compared the performance of students in high technology programs in engineering and computer science are presented, with emphasis on students' mathematical preparation. The study population involved 175 transfer students who completed their mathematical prerequisites at three community colleges and 188 students who completed their prerequisites at the university. The community college sample included all students who completed the two calculus prerequisites with a final grade of "D" or above and subsequently enrolled at the university in one of the high technology programs between 1979 and 1983. The university subpopulation was a stratified random sample of those students who completed the calculus prerequisites with a final grade of "D" or above and enrolled in the high technology programs during the same time period. The findings revealed that a substantially greater percentage of the students who completed the calculus sequence at the community college received grades of "C" or higher. Further, it was found that academic performance in those engineering and computer science courses that required calculus as a prerequisite was independent of the type of institution in which the calculus sequence was completed. (Author/SW)

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STUDENT ACHIEVEMENT IN HIGH TECHNOLOGY PROGRAMS—
COMMUNITY COLLEGE VS. UNIVERSITY MATHEMATICAL PREPARATION

Presented at

Twenty-Fourth Annual AIR Forum

Fort Worth, Texas

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May, 1984

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THE ASSOCIATION FOR INSTITUTIONAL RESEARCH

This paper was presented at the Twenty-Fourth Annual Forum of the Association for Institutional Research held at the Hyatt-Regency in Fort Worth, Texas, May 6-9, 1984. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum papers.

Daniel R. Coleman, Chairman
Forum Publication
Advisory Committee

ABSTRACT

The paper presents the findings of a study which compares the performance of students in high technology programs in Engineering and Computer Science with particular emphasis on students' mathematical preparation. The population of this study involved a group of students who completed their mathematical prerequisites at three community colleges and a group who completed their prerequisites at the university. These findings revealed that a substantially greater percentage of the students who completed the calculus sequence at the community college received grades of C or higher. Further, it was revealed that academic performance in those engineering and computer science courses which require calculus as a prerequisite was independent of type of institution in which the calculus sequence was completed.

STUDENT ACHIEVEMENT IN HIGH TECHNOLOGY PROGRAMS COMMUNITY COLLEGE VS. UNIVERSITY MATHEMATICAL PREPARATION

Introduction

The demand for high technology graduates throughout the next decade will continue to out-pace available manpower. Peter Larson (1982) reported that 250,000 engineers would graduate in the Soviet Union compared to 65,000 in the United States during 1982. It is projected that the current shortage of high technology manpower will become more critical and the United States will have to import high technology competency to meet industrial needs during the next decade.

Attrition in applied high technology programs is justifiably high due to the specific curricular requirements and the applied nature of the profession. Larson (1982) reported that a mere 5% of the baccalaureate degrees awarded in the United States are in engineering compared to 45% in the Eastern Block nations. The failure of many bright students to successfully complete their mathematical prerequisite requirements contributes immensely to the problem. It is not atypical for less than 40% of a college algebra class or a first year calculus class to successfully complete the course in many institutions. Although it is commonly accepted that poor student preparation accounts for this level of performance, the through-put rate for mathematics courses is usually greater in the community college setting.

Purpose

The purpose of this study was to assess the performance level of majors in high technology programs (Engineering and Computer Science) who completed their calculus prerequisites at three community colleges with the performance level of a group of students who completed their calculus prerequisites at the university. The specific objectives were:

1. To determine if the Calculus I and Calculus II through-put rate was dependent on institution type (Community College or University).
2. To determine if achievement in high technology courses in which Calculus I and Calculus II were prerequisites was dependent on type of institution in which these courses were completed.

Historical Overview

A review of the literature revealed numerous studies which compared the performance of community college transfers with their native peers. During the past two decades, studies by Knoell (1965), Medsker (1960), Hill (1965), and Nolan and Hall (1978) reported that although community college students may suffer from transfer shock initially, they perform as well as their native peers once they have adjusted to the new environment.

Bolte and Coleman (1979) reported minor differences between the completion rate for community college transfers and native university students when academic discipline was considered. They reported that a greater proportion of native students majored in engineering, mathematical sciences and physical sciences whereas a greater proportion of the community college transfers majored in education and public affairs.

Flag (1983) reported that students who completed two years at a community college prior to enrolling at the university were as successful in completing the Biological Sciences curricula as their native university peers. Flag stratified the two populations by admission test score category in completing the analysis.

The Study

The population for this study included 175 transfer students who completed their Calculus I and Calculus II prerequisites at one of three community colleges and 188

students who completed similar calculus courses at the university. All of the community college students who completed the two calculus prerequisites with a final grade of D or above at one of the three institutions and subsequently enrolled at the university in one of the high technology programs between 1979 and 1983 were included in the population. The university sub-population was a stratified random sample of those students who completed the calculus prerequisites at the university with a final grade of D or above and enrolled in one of the high technology programs during the same time period.

Student performance, academic program and aptitude data were taken from the student record systems of the three community colleges and the university. Grade distribution data were provided by each of the participating institutions.

The analysis of achievement level in high technology courses was limited to those engineering or computer science courses that identified Calculus I and Calculus II as prerequisites. Eighty-seven engineering courses and fourteen computer science courses were identified for inclusion. Each student included in this analysis had completed one or more of the prescribed courses. A non-parametric chi square analysis and a test on the difference of two population means for independent samples using the z-statistic were used to test the null hypotheses of no difference in the calculus grade distributions and the average performance by area of study. All null hypotheses were tested for significance at the 5 percent level.

It was hypothesized that the type of institution in which Calculus I and Calculus II were completed was independent of academic performance in high technology courses which required calculus as a prerequisite.

Presentation of Findings

The academic performance of Engineering and Computer Science high technology

majors for those students who completed their calculus prerequisites at a community college or the university was similar. In general, both sub-populations were successful in completing the high technology curricula. Since students from both groups were academically successful, the output of engineering graduates could be dependent on the type of institution students choose to complete their calculus prerequisites.

Calculus Grading Patterns

Table I provides a summary of the percent of grades awarded in the calculus courses by type of institution and grade categories. The grade categories were above satisfactory (A/B), satisfactory (C), unsatisfactory (D/F) and withdrawal (W). A chi square analysis was used to test the null hypothesis of independence for each of the calculus grade distributions by type of institution to determine if the calculus throughput rate was dependent on type of institution.

Table 1
Summary of Percent of Grades Awarded by Course,
Type Institution & Grade Category

Grade	Calculus I		Calculus II		Calculus III	
Category	Com. Col.	Univ.	Com. Col.	Univ.	Com. Col.	Univ.
A or B	39.0%	24.6%	38.9%	20.2%	48.2%	25.5%
C	18.4%	19.9%	20.6%	19.8%	21.9%	27.9%
D or F	13.7%	35.0%	11.2%	32.8%	11.4%	27.7%
W	28.9%	20.5%	29.3%	27.2%	18.5%	18.9%
Number of Grades Awarded*	2394	1765	1162	1126	699	556

Source: Institutional class rolls.

*These figures do not include incompletes or audit grades. Percentage figures were based on the number of grades awarded in the specific grade categories listed.

A greater proportion of the community college students successfully completed Calculus I than their university peers. The percentage of students that successfully completed Calculus I, with a grade of C or above, at the community college was 57.4% compared to 44.5% at the university. In Calculus I, 39.0% of the grades awarded at the community college were A/B grades compared to 24.6% at the university. The percentage of C grades were quite similar in each case. The percentage of D/F grades awarded at the community college was 13.7% compared to 35.0% at the university. The percentage of W's awarded at the community college was 28.9% compared to 20.5% at the university. Since the withdrawal period at the community college was longer than the corresponding period at the university, one would anticipate a difference in the D/F and W distributions. The null hypothesis of independence was rejected at the 5 percent level of significance. Therefore, one could conclude that the through-put rate in Calculus I is dependent on type of institution.

A comparison of the Calculus II grade distributions revealed findings similar to those observed for Calculus I. The percentage of students that successfully completed Calculus II at the community college was 59.5% compared to 40.0% at the university. The percentage of A/B grades awarded at the community college was 38.9% compared to 20.2% at the university. The percentage of C and W grades awarded were quite similar for both groups. However, the percentage of D/F grades awarded at the community college was 11.2% compared to 32.8% at the university. The null hypothesis of independence was rejected at the 5 percent level of significance. Therefore, one could conclude that the through-put rate in Calculus II is dependent on type of institution.

A comparison of the Calculus III distributions revealed similar findings to those observed for Calculus II. The Calculus III success rate was 70.1% at the community college compared to 53.4% at the university. At the community college 48.2% of the grades awarded were A's or B's compared to 25.5% at the university. The percent of C

grades awarded at the university was 27.9% compared to 21.9% at the community college. The percent of D/F grades awarded at the community college was 11.4% as compared to 27.7% at the university. The percent of W's were virtually the same for both groups. The null hypothesis of independence was rejected at the 5 percent level of significance. Thus, one could conclude that Calculus III through-put rate is dependent on type of institution.

In summary the overall through-put rate for the calculus sequence was dependent on type of institution. Further, it was revealed that there was a substantially greater percentage of students from community college receiving grades of C or higher in each of the calculus courses.

Engineering Performance

Table II provides a summary of the engineering course grade point average by grade

Table 2
Summary of Average Engineering Course Grade
Point Average* by Grade Interval
And Type Institution

Grade Interval	Type Institution**			
	Community College		University	
	Number	Percent	Number	Percent
3.50 or above	11	8.6%	7	6.0%
3.00 to 3.49	23	18.0%	28	23.9%
2.50 to 2.99	36	28.1%	33	28.2%
2.00 to 2.49	44	34.4%	39	33.3%
Less than 2.00	14	10.9%	10	8.6%
Total	128	100%	117	100%
Avg. No. Hours	35.5		23	
Mean	2.580		2.603	
Standard Deviation	.60		.57	

* The grade point average was based on those grades awarded in those engineering courses in which Calculus I and Calculus II were prerequisites.

** Type of institution in which Calculus I and Calculus II was completed.

interval and type of institution for those engineering courses requiring Calculus I and Calculus II as prerequisites. These data revealed that 26.6% of the students who completed their calculus sequence at the community college and 29.9% of those who completed the corresponding sequence at the university attained a grade point average of 3.0 or above in the engineering courses. The percent of grades awarded in the other grade categories were virtually equal. A comparison of the overall success rate revealed that 89.1% of those students who completed their calculus sequence at the community college and 91.4% of those who completed the corresponding sequence at the university maintained a grade point average of 2.0 or above in those engineering courses requiring calculus as a prerequisite. This represented a net difference of 2.3 percentage points.

A comparison of the group mean performance revealed a grade point average of 2.603 for the university group compared to 2.580 for the community college group. A test on the difference of the two population means for independent samples using the z-statistic was used to test the null hypothesis of no difference in mean performance by group. There was insufficient evidence to reject the null hypothesis at the 5 percent level of significance. Therefore, one could conclude that academic performance in those engineering courses which require calculus as a prerequisite was independent of the type of institution in which the calculus sequence was completed.

A Pearson product moment coefficient of correlation was computed between the Calculus I and Calculus II average grade and the engineering grade point average for the selected courses. This analysis revealed correlation coefficients of $r = .49$ for the university group and $r = .37$ for the community college group. Thus, the degree of association between performance in the engineering courses and the required calculus prerequisite is moderate to low.

Quantitative scholastic aptitude test scores were only available for 24 of the 128 engineering majors who completed their calculus prerequisite at the community college.

Therefore, analyses beyond mean performance was inappropriate. A test on the difference of two population means for independent samples using the student t-statistic was used to test the null hypotheses of no difference between the performance of those community college students with and without aptitude test scores. Null hypotheses were tested for both the average calculus grades and the average engineering course grades. In each case, insufficient evidence was provided to reject the null hypotheses at the 5 percent level of significance. Therefore, one could conclude that those students from the community college without aptitude test scores were from the same population as those with aptitude test scores. A comparison of the quantitative test scores for the university population and the community college population revealed average scores of 581 and 556 respectively.

Computer Science Performance

Table III provides a summary of the computer science course grade point average by grade interval and type of institution for those computer science courses requiring Calculus I and Calculus II as prerequisites. These data revealed that 53.2% of the students who completed their calculus sequence at the community college and 55.0% of those who completed the corresponding sequence at the university attained a grade point average of 3.0 or above. The percentage of grades awarded in the other grade categories were virtually equal. A comparison of the overall success rate revealed that 89.4% of those students who completed their calculus sequence at the community college compared to 91.6% of those who completed the corresponding sequence at the university maintained a grade point average of 2.0 or above in those computer science courses requiring calculus as a prerequisite. The number of computer science courses completed which requires the calculus sequence as a prerequisite was limited for both groups.

A comparison of the group mean performance revealed a grade point average of 2.799 for the university group compared to 2.684 for the community college group. A test on the difference between two population means for independent samples using the z-statistic was used to test the null hypothesis of no difference in mean performance by

Table 3
Summary of Average Computer Science Course Grade
Point Average* by Grade Interval
And Type Institution

Grade Interval	Type Institution**			
	Community College		University	
	Number	Percent	Number	Percent
3.50 or above	7	14.9%	18	25.4%
3.00 to 3.49	18	38.3%	21	29.6%
2.50 to 2.99	7	14.9%	11	15.5%
2.00 to 2.49	10	21.3%	15	21.1%
Less than 2.00	5	10.6%	6	8.4%
Total	47	100%	71	100%
Avg. No. Hours	8.3		10.0	
Mean	2.684		2.799	
Standard Deviation	.775		.785	

* The grade point average was based on those grades awarded in those computer science courses in which Calculus I and Calculus II were prerequisites.

** Type of institution in which Calculus I and Calculus II was completed.

group. These data did not provide sufficient evidence to reject the null hypothesis at the 5 percent level of significance. Therefore, one could conclude that academic performance in those computer science courses which require calculus as a prerequisite was independent of the type of institution in which the calculus sequence was completed.

A Pearson product moment coefficient of correlation was computed between the Calculus I and Calculus II average grade and the computer science course grade point average for the selected courses. This analysis revealed correlation coefficients of $r = .48$ for the university group and $r = .60$ for the community college group. Thus, the

degree of association between performance in the engineering courses and the required calculus prerequisite was moderate in each case.

Quantitative scholastic aptitude test scores were only available for 14 of the 47 computer science majors who completed their calculus prerequisite at the community college. Therefore, analyses beyond mean performance was inappropriate. A test on the difference of two population means for independent samples using the student t-statistic was used to test the null hypotheses of no difference between the performance of those community college students with and without aptitude test scores. Null hypotheses were tested for both the average calculus grades and the average computer science course grades. In each case, insufficient evidence was provided to reject the null hypotheses at the 5 percent level of significance. Therefore, one could conclude that those students from the community college without aptitude test scores were from the same population as those with aptitude test scores. A comparison of the quantitative test scores for the university population and the community college population revealed average aptitude test scores of 566 for both groups.

Summary and Conclusion

The findings of this study revealed that approximately 90% of those students who completed the Calculus I and Calculus II sequence at the community college or university maintained grade point averages of 2.0 or above in those engineering and computer science courses which required Calculus I and Calculus II as prerequisites. In general, one would conclude that the mathematical preparation provided by the community college and university mathematics departments was adequate for those students majoring in the high technology programs of computer science and engineering.

An analysis of the through-put rate for calculus courses revealed a statistically significant difference in the distribution of grades for each of the calculus courses by

type of institution. It was revealed that a substantially greater percentage of students from the community college received grades of C or higher in each of the calculus courses. In general, a greater proportion of the successful students who attended the community college received grades in the A/B category compared to their university peers. Conversely, a greater proportion of the university students received grades in the D/F category.

Both community college and university students were successful in completing engineering courses which required calculus as a prerequisite. A comparison of the overall success rate revealed that 89.1% of those students who completed their calculus sequence at the community college and 91.4% of those who completed the corresponding sequence at the university maintained a satisfactory grade point average in those engineering courses requiring calculus as a prerequisite. The analyses did not reveal a statistically significant difference among the performance of the two populations. Therefore, one could conclude that performance in engineering courses was independent of institution in which the calculus prerequisites were completed.

The computer science students were equally successful to the engineering students. This study revealed that 89.4% of the computer science students who completed the calculus sequence at the community college and 91.6% of those who completed the corresponding sequence at the university maintained a grade point average of 2.0 or above in those computer science courses requiring calculus as a prerequisite. The analysis did not provide sufficient evidence to reject the null hypotheses of no difference. Therefore, one could conclude that the performance in computer science courses is independent of type of institution in which a student completed the calculus prerequisites.

The findings of this study revealed that the degree of association between academic performance in the calculus sequence and those computer science or

engineering courses which required calculus as a prerequisite was moderate to low. However, a vast majority of students enrolling in the university in either computer science or engineering were successful in completing the academic curricula regardless of where the calculus prerequisites were completed. Since academic performance in those courses which required calculus as a prerequisite was found to be independent of type of institution in which the calculus sequence was completed, steps should be taken to determine what accounts for the greater calculus through-put rate of those students who completed their mathematical prerequisite courses at the community college. If, in fact, there will be a shortage of engineering graduates in the United States to successfully staff a rapidly growing high technology industry during the next decade, it is conceivable that the available engineering manpower pool can be increased through approved articulation with community colleges or modification of the calculus prerequisite sequence.

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